

XPRIZE
WILDFIRE

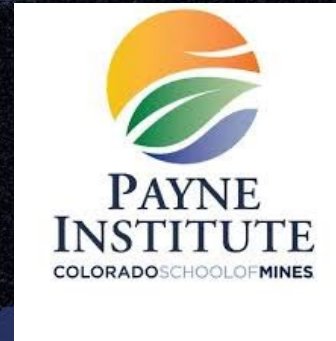
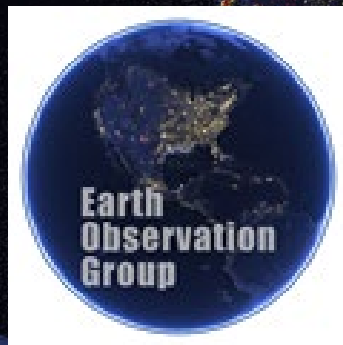


GORDON AND BETTY
MOORE
FOUNDATION

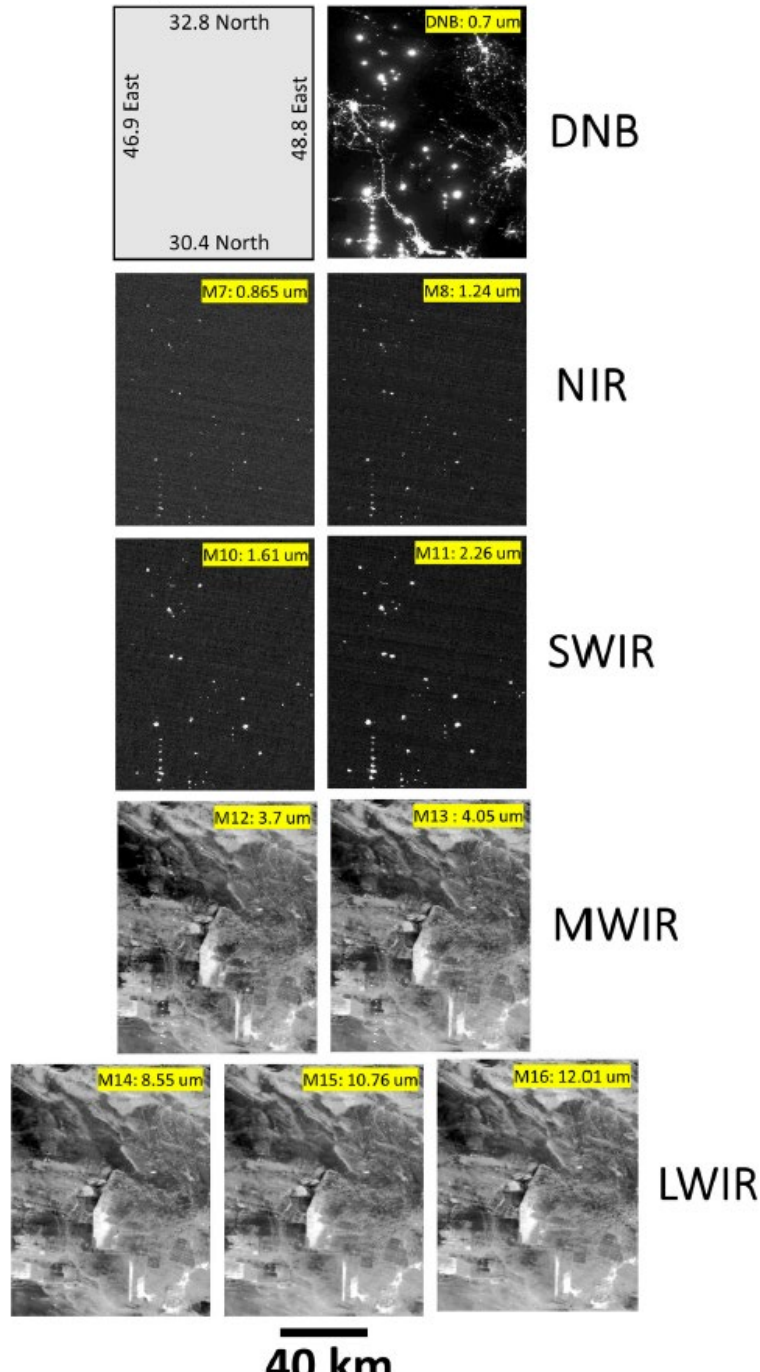
VIIRS Nightfire – Flaming and Non-Flaming Combustion From Space

Christopher D. Elvidge, Mikhail Zhizhin, Tilottama Ghosh, Tamara Sparks, Stephen Pon
Earth Observation Group
Payne Institute for Public Policy
Colorado School of Mines

Golden, Colorado
celvidge@mines.edu
February 2nd, 2024



Basra, Iraq March 22, 2018

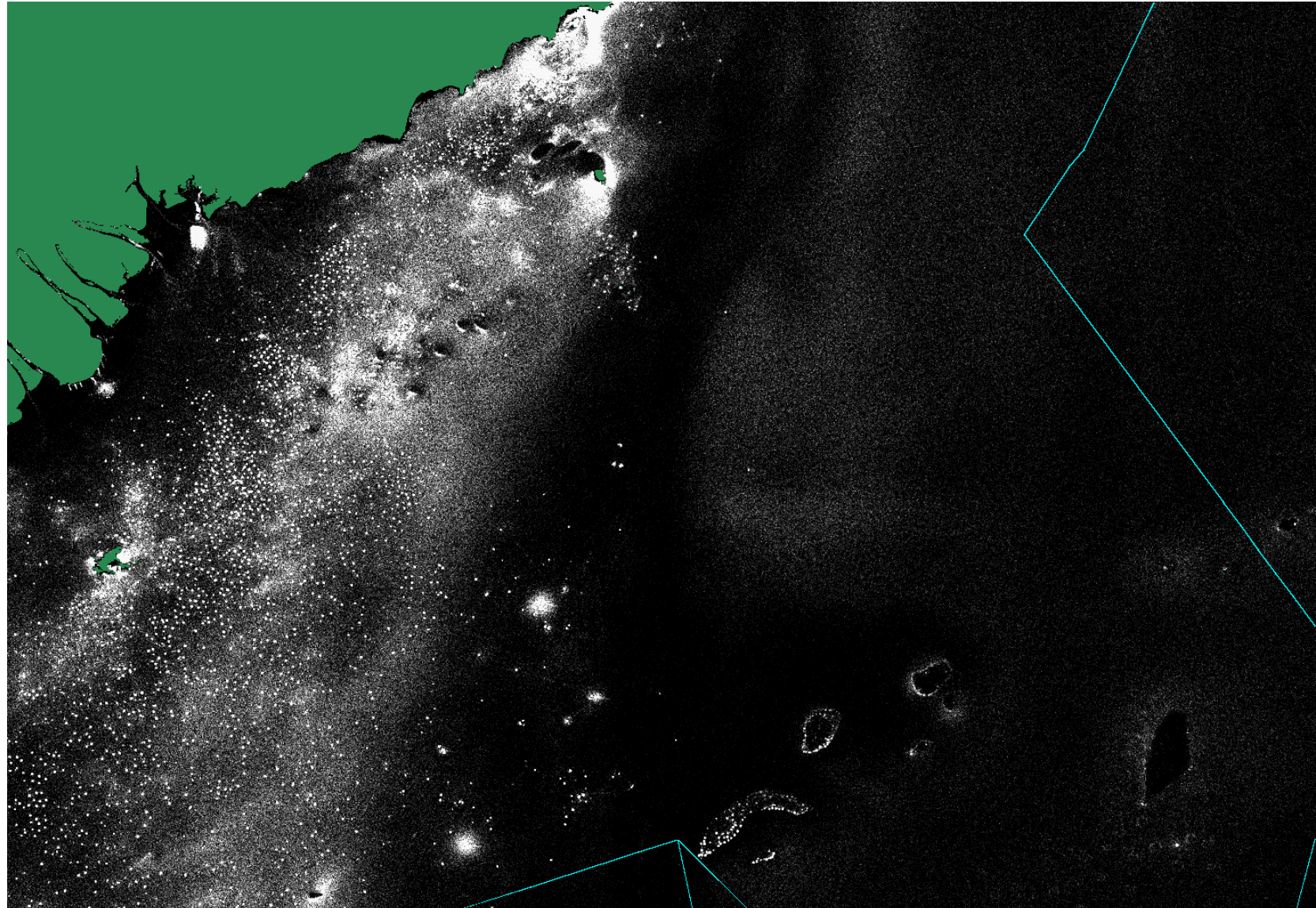
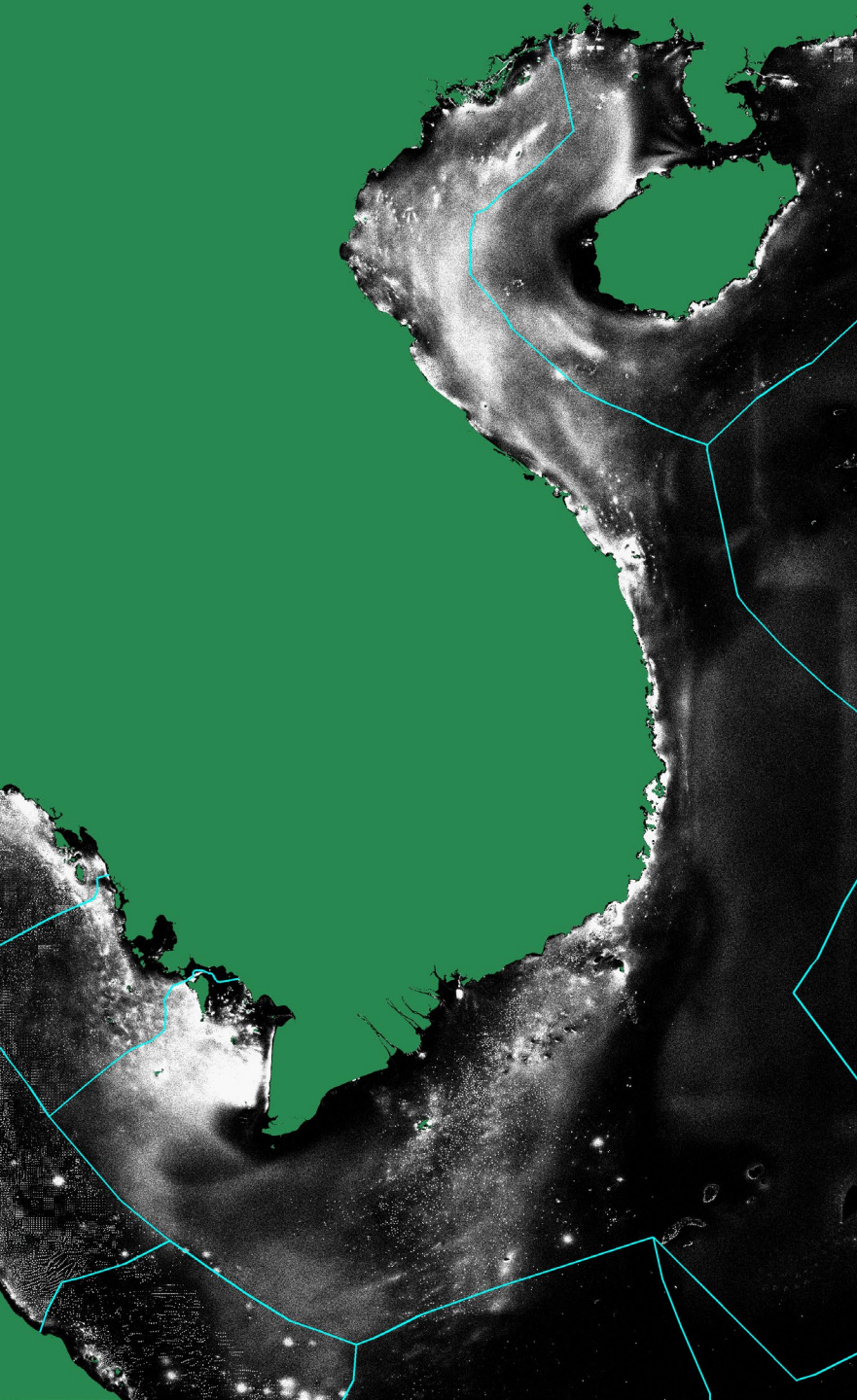


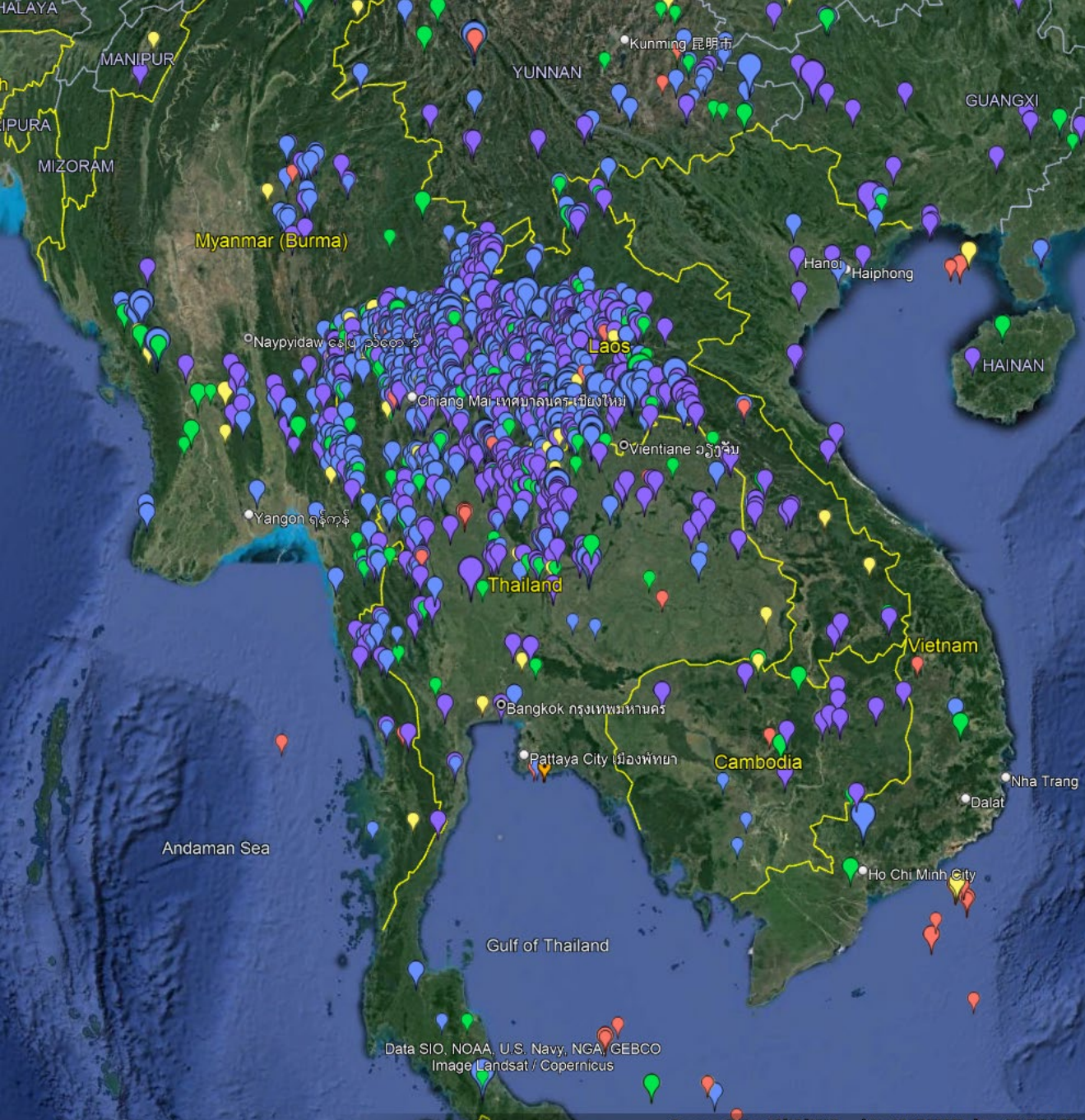
VIIRS is unique in collecting data in four near and shortwave infrared channels at night. These channels are designed for daytime imaging. At night – they serve as super-detectors for infrared emitters!



VIIRS Nighttime
Lights – Hanoi -
2022

Eleven-year accumulation of
nightly VIIRS boat detections





VIIRS Nightfire v.3

April 1, 2023



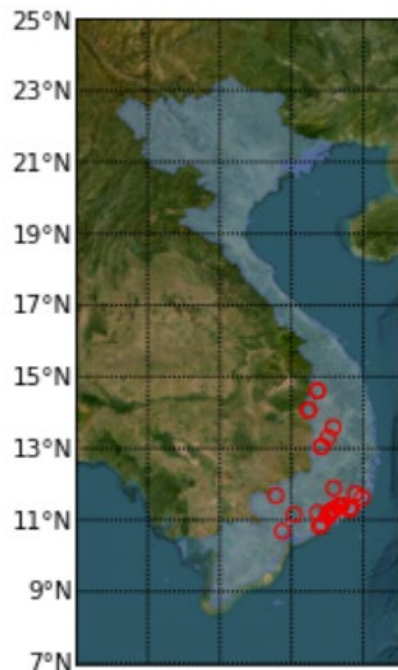
VIIRS Nightfire Vietnam All Region Daily Summary 2024-01-29

[\[CSV\]](#)[\[KML\]](#) Note: These links are valid for 14 days.

Total detections: 35

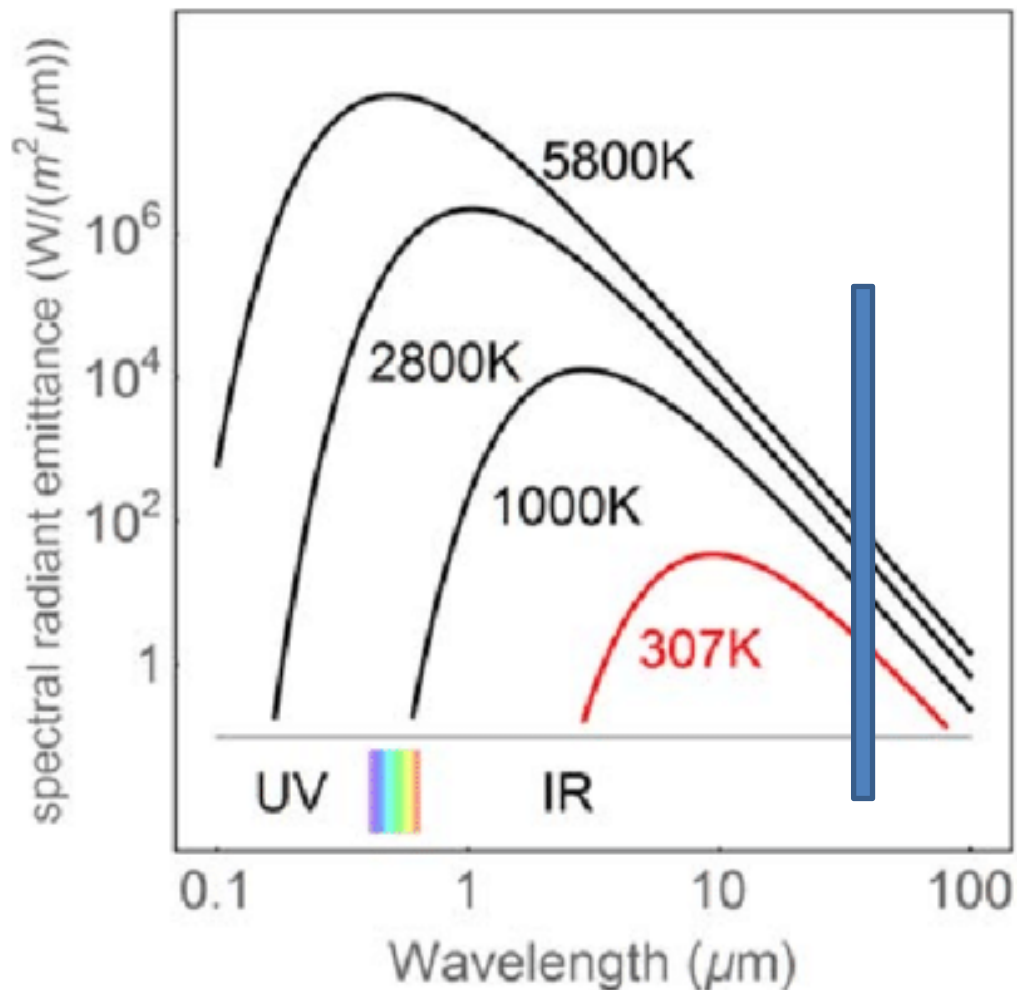
Alert is sent because at least one orbit is complete.

There are new data in this alert.



EOG sends VBD and VNF detections at about 06:00 local time. Alerts run for Vietnam, Thailand, Indonesia and S.E. Asia. Let us know if you want alerts!

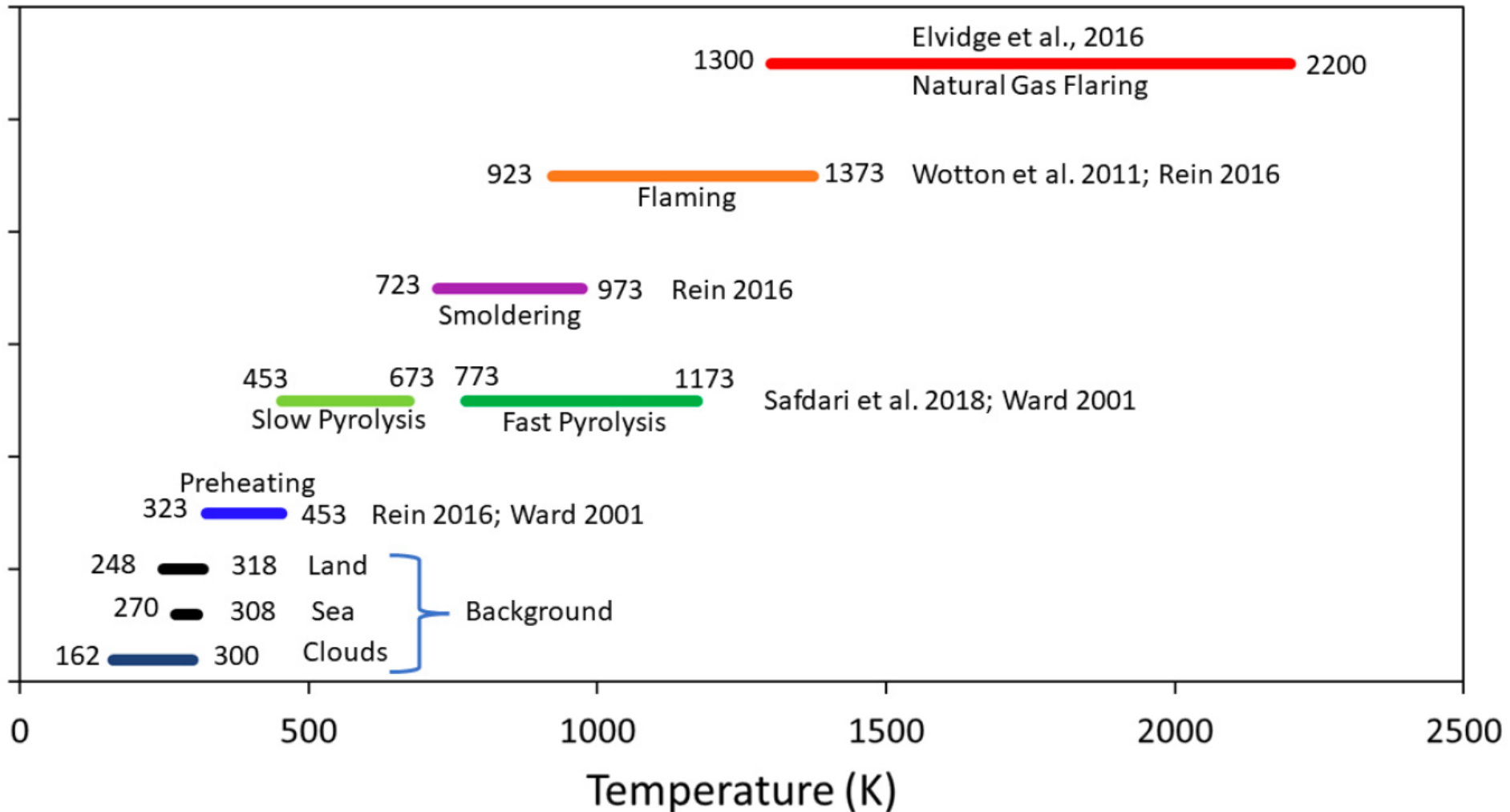
If an object fills the field of view – its temperature can be calculated from the radiance in a single spectral band



Planck curve lines for full pixel objects do not cross each other. Thus, the objects temperature can be calculated with the observed radiance in a single spectral band. The situation is more complicated for subpixel IR emitters.

Biomass Burning is a Coupled Exothermic / Endothermic System

Temperature Ranges of Fire Pixel Components



Flaring, flaming, and smoldering are exothermic – giving off heat. Pyrolysis is driven by the heat emitted by flaming and smoldering. Flaming combustion is fed by volatile gases released by pyrolysis.

Environmental Research Letters

LETTER

Long-wave infrared identification of smoldering peat fires in Indonesia with nighttime Landsat data

Christopher D Elvidge¹, Mikhail Zhizhin^{2,3}, Feng-Chi Hsu², Kimberly Baugh², M Rokhis Khomarudin⁴, Yenni Vetrina⁴, Parwati Sofan⁴, Suwarsono⁴ and Dadang Hilman⁵

¹ Earth Observation Group, NOAA National Geophysical Data Center, 325 Broadway, Boulder, Colorado 80305, USA

² Cooperative Institute for Research in the Environmental Sciences, University of Colorado, Boulder, Colorado, USA

³ Space Research Institute, Russian Academy of Sciences, Moscow, Russia

⁴ National Institute of Aeronautics and Space (LAPAN), Jakarta, Indonesia

⁵ Indonesia Climate Change Center, Jakarta, Indonesia

2015 paper
on flaming
vs non-
flaming
peatland
fires with
nighttime
Landsat

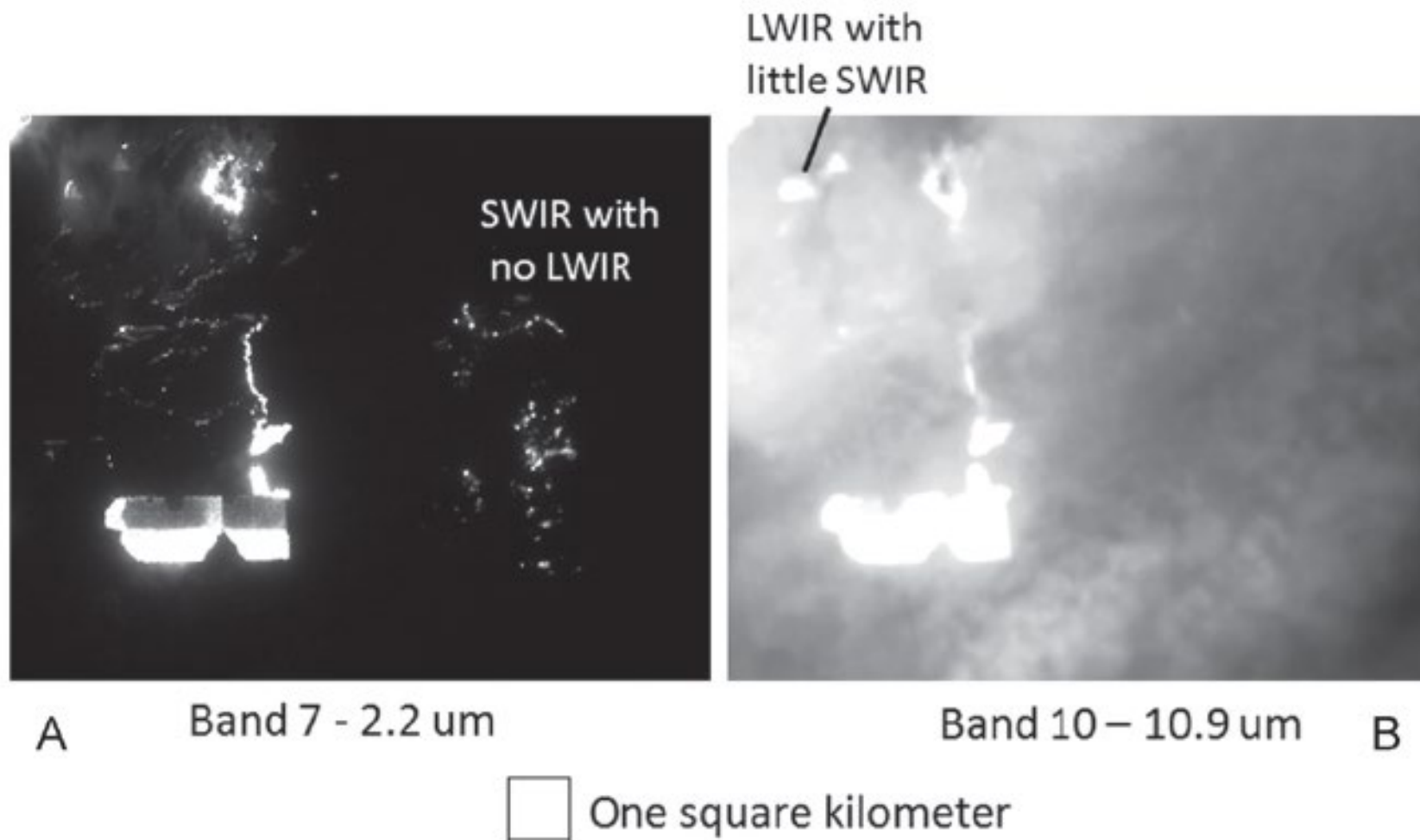


Figure 7. In most cases the LWIR and SWIR active fire features are co-located. But it is possible to find SWIR detections that lack LWIR thermal anomalies. This is an indication of flaming phase fires that have not initiated smoldering. (A) Band 7 image showing areas with active fires that are not present in the LWIR. (B) Band 10 image showing active fires that are faintly expressed in the SWIR.

Examples of SWIR only, LWIR only and both, implying two combustion phases.

Rudiments of the Flaming-Subtractive Algorithm in 2015

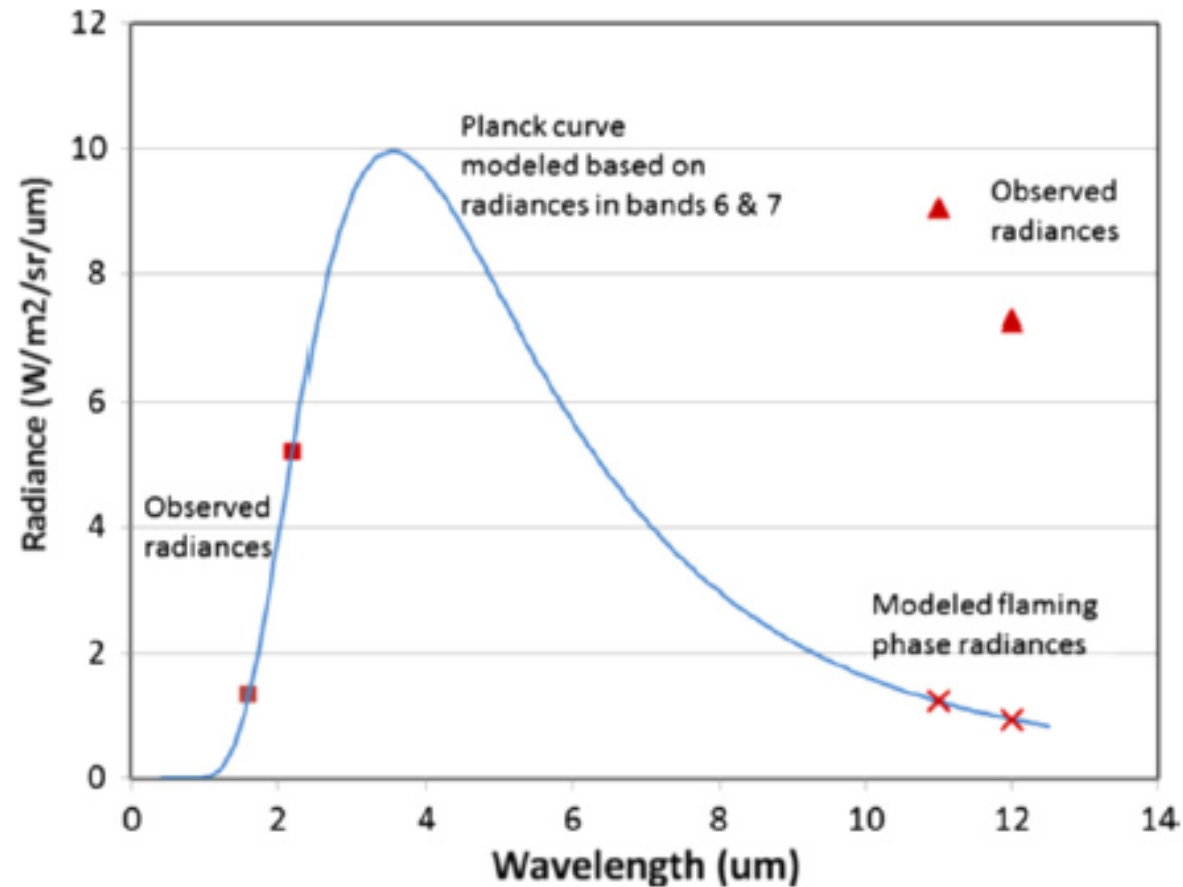


Figure 4. The flaming phase radiances in the LWIR can be modeled with the two SWIR band radiances via Planck curve fitting. The fitting indicates the flaming phase temperature is 825 K. The radiances in bands 10 and 12 are comparable to the radiance in band 6.

Identification of Smoldering Peatland Fires in Indonesia via Triple-Phase Temperature Analysis of VIIRS Nighttime Data

By Christopher D. Elvidge, Mikhail Zhizhin, Kimberly Baugh, Feng-Chi Hsu

Book [Biomass Burning in South and Southeast Asia](#)

Edition 1st Edition

First Published 2021





Flaming
subtractive
method
applied to
VIIRS.
Book editor
was Krishna!

Physical laws used by VIIRS Nightfire

- Temperature is calculated based on the wavelength of peak radiant emissions using **Wien's Displacement Law**.
- Source area is calculated based on the ratio of the observed Planck curve amplitude versus the Planck for an object at that temperature filling the field of view (**Planck's Law**).
- Heat output (radiant heat) is calculated with temperature and source area via the **Stefan-Boltzmann Law**.

Article

Subpixel Analysis of Primary and Secondary Infrared Emitters with Nighttime VIIRS Data

Christopher D. Elvidge ^{1,*} , Mikhail Zhizhin ^{1,2} , Feng Chi Hsu ¹ , Tamara Sparks ¹ and Tilottama Ghosh ¹ 

¹ Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines, Golden, CO 80401, USA; mzhizhin@mines.edu (M.Z.); fengchihsu@mines.edu (F.C.H.); tsparks@mines.edu (T.S.); tghosh@mines.edu (T.G.)

² Russian Space Research Institute, Moscow 117810, Russia

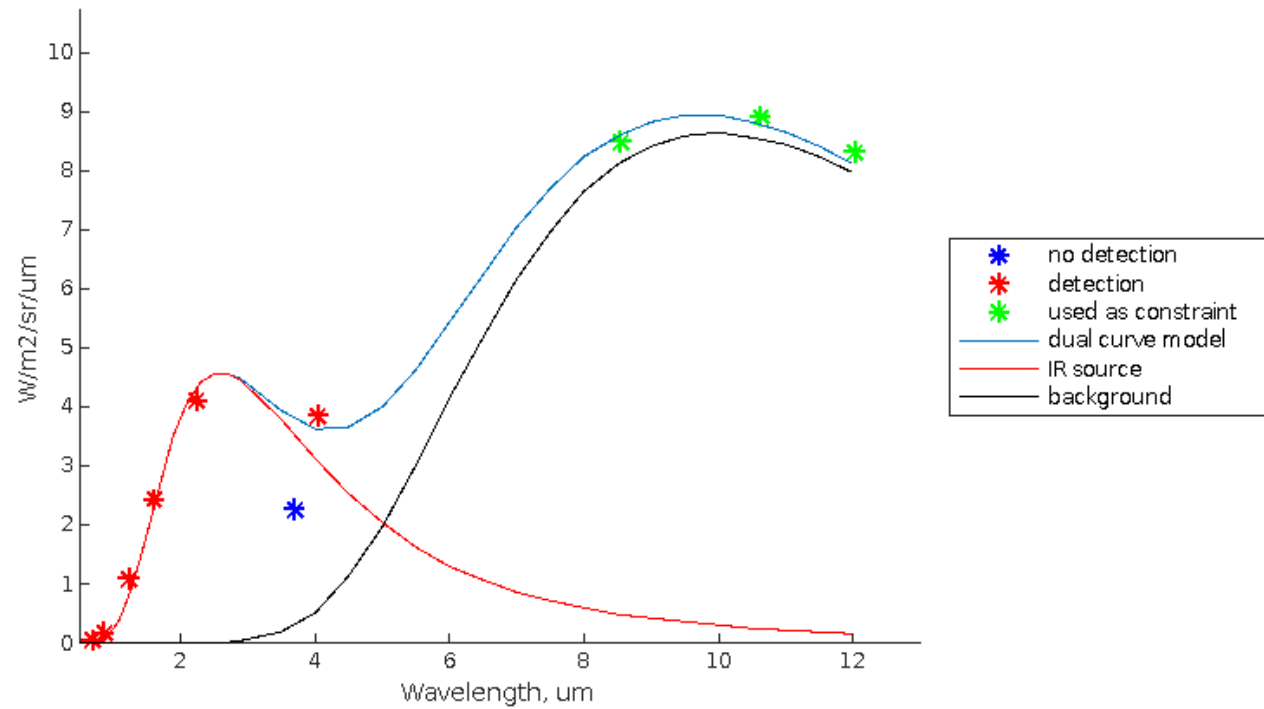
* Correspondence: celvidge@mines.edu

Abstract: Biomass burning is a coupled exothermic/endergonic system that transfers carbon in several forms to the atmosphere, ultimately leaving mineral ash. The exothermic phases include flaming and smoldering, which produce the heat that drives the endothermic processes. The endothermic components include pre-heating and pyrolysis, which produce the fuel consumed by flaming and smoldering. These components can be broadly distinguished from each other based on temperature. For several years, we have researched the subpixel analysis of two temperature phases present in fire pixels detected in nighttime VIIRS data. Here, we present the flaming subtractive method, with

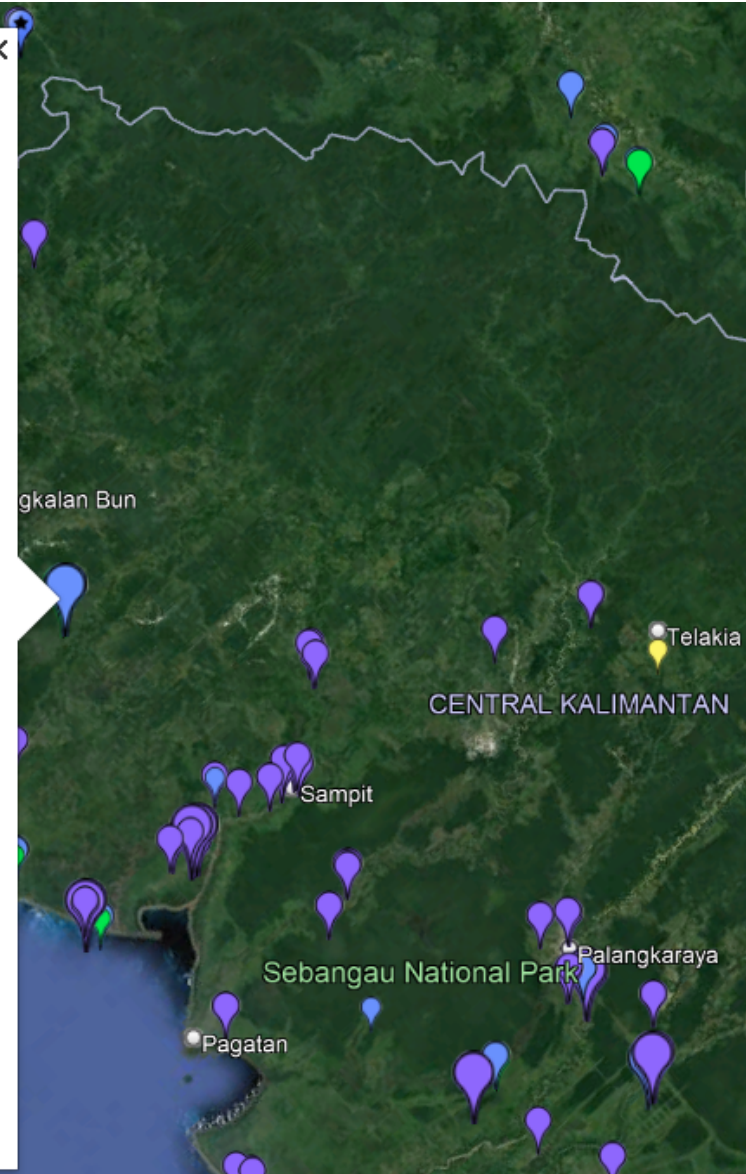
VNF v.4 nightly global processing started September 1, 2023 – eight years after the nighttime Landsat paper. VNF v.4 has atmospheric correction and tests VNF detections having SWIR and MWIR detection for the presence of secondary emitters. This testing has a ~50% success in identifying secondary emitters.

VNF v.3 biomass burning in Kalimantan, Indonesia September 1, 2023

ID = VNF npp d20230901 t1745082 e1746324 b61380 x1120795E y026633S 10292 s1246 v30
Lat = -2.6633 Lon = 112.0795 deg. Time = 2023-09-01 17:45:40 UTC
Temperature source = 1114 K Temperature background = 292 K
Radiant heat intensity = 56.84 W/m² Radiative heat = 40.01 MW
Source footprint = 457.41 m² Local time = 2023/09/02 00:45:40
Cloud state = clear Atmosphere corrected = no
File = SVM10 npp d20230901 t1745082 e1746324 b61380 c20230901190533376000 oebc ops.h5



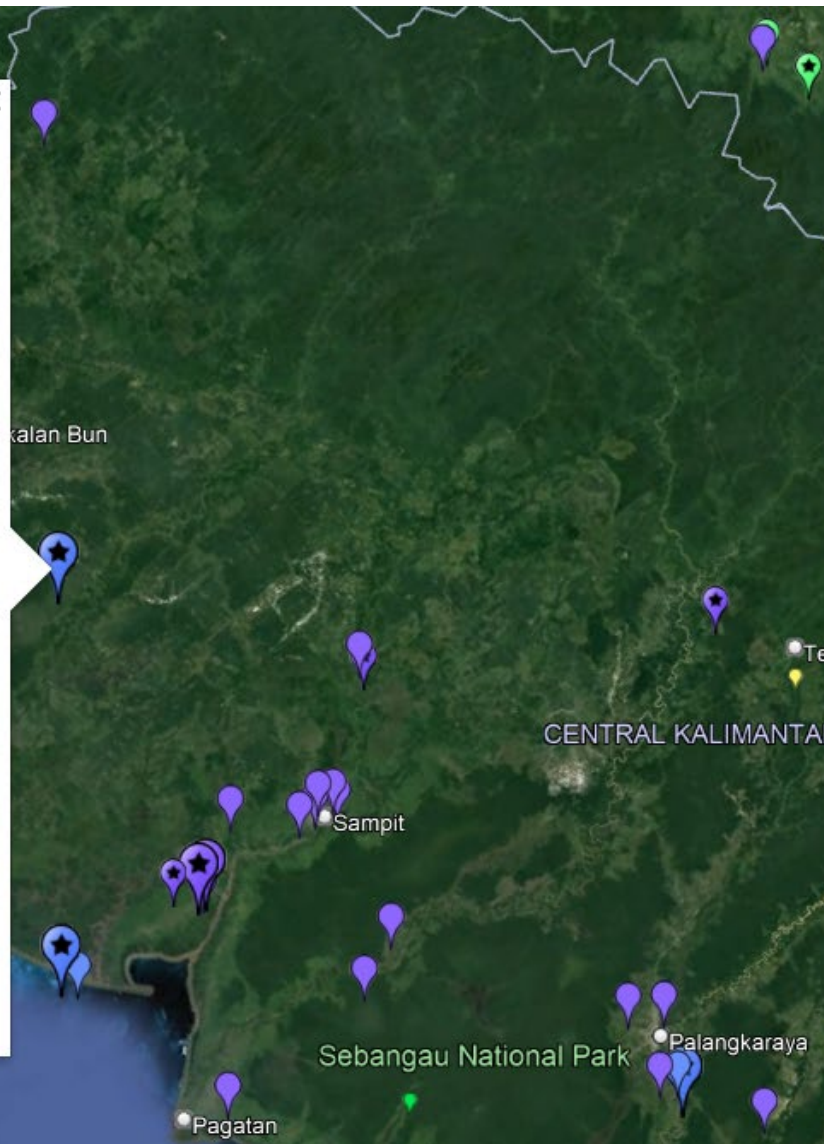
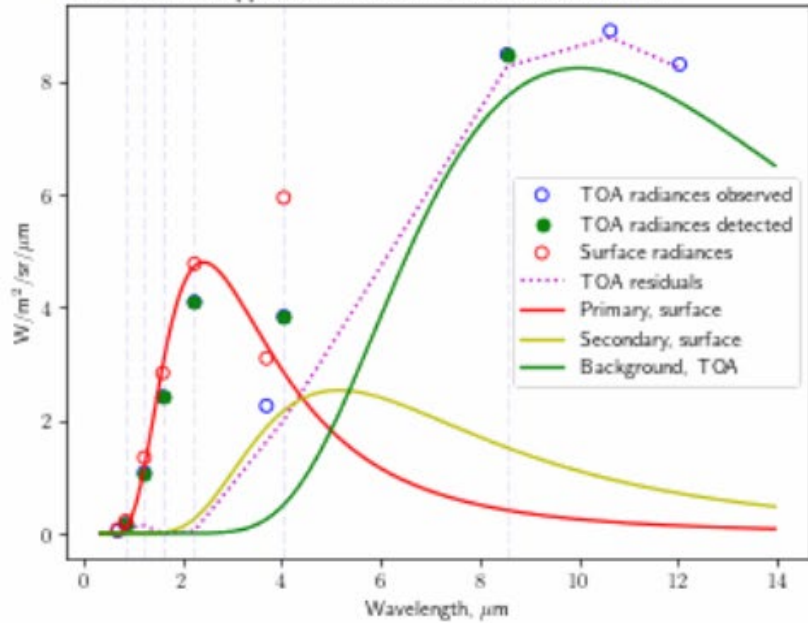
Directions: [To here](#) - [From here](#)



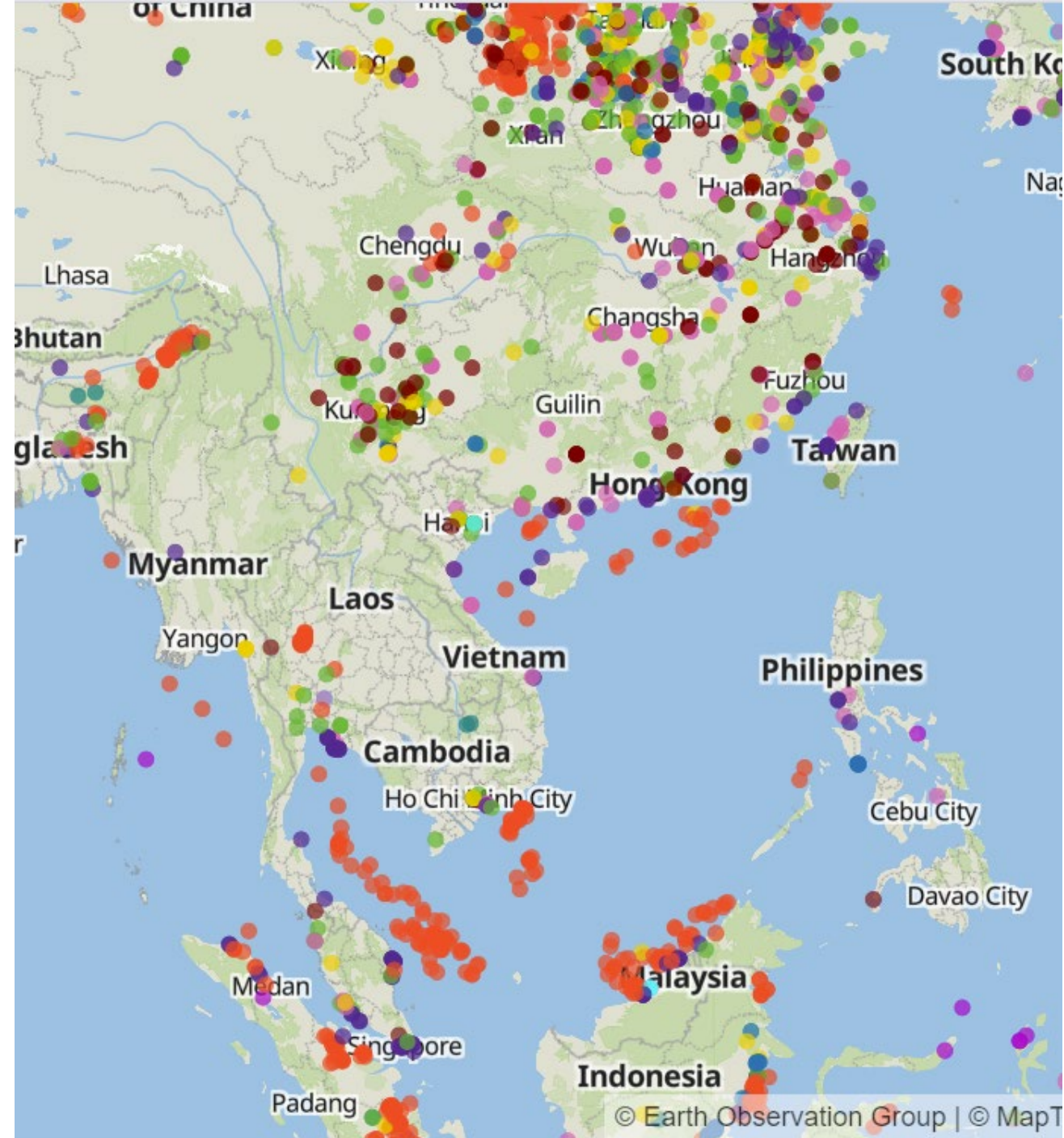
d20230901_t174540_x1120795E_y026633S_I0292_s1246_v4.0

ID = d20230901.t174540.x1120795E.y026633S.I0292.s1246.v4.0
Lat = -2.6633 Lon = 112.0795 deg. UTC time = 2023-09-01 17:45:40
T background = 290 K Local time = 2023-09-01 17:45:40
T primary = 1192 K Primary footprint = 343.0 m²
T secondary = 562 K Secondary footprint = 7783.7 m²
Cloud state = clear Atmosphere corrected = yes
File = SVM10_npp_d20230901.t1745082_e1746324_b61380

Emitter:
Directions:
[To here](#) -
[From here](#)

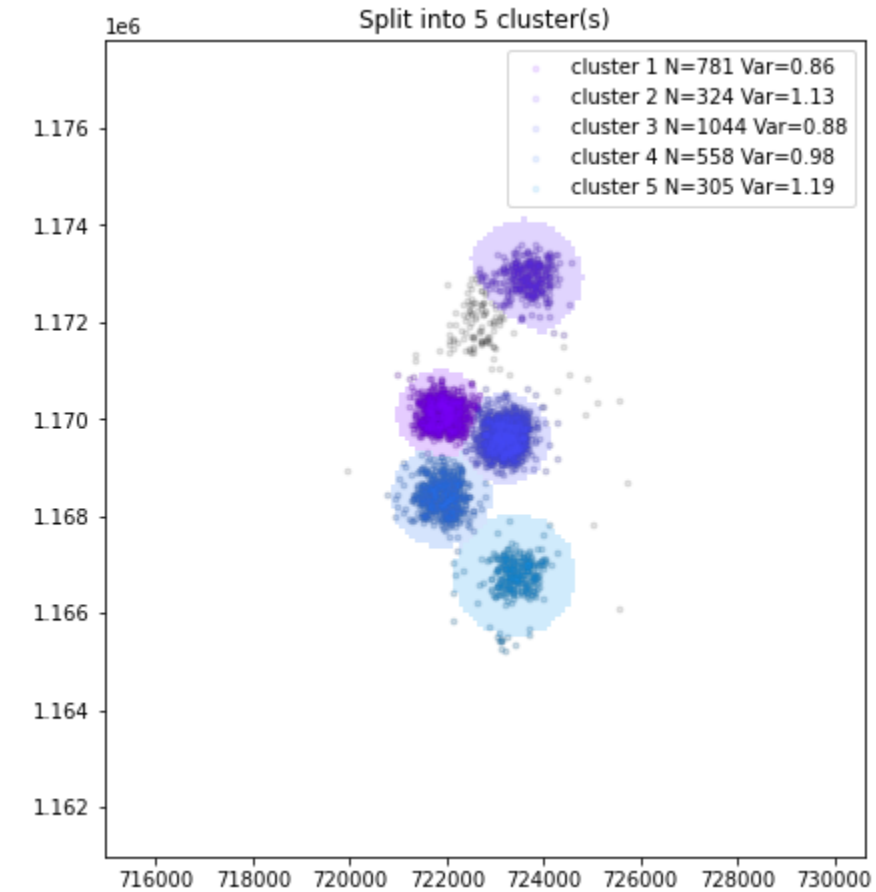
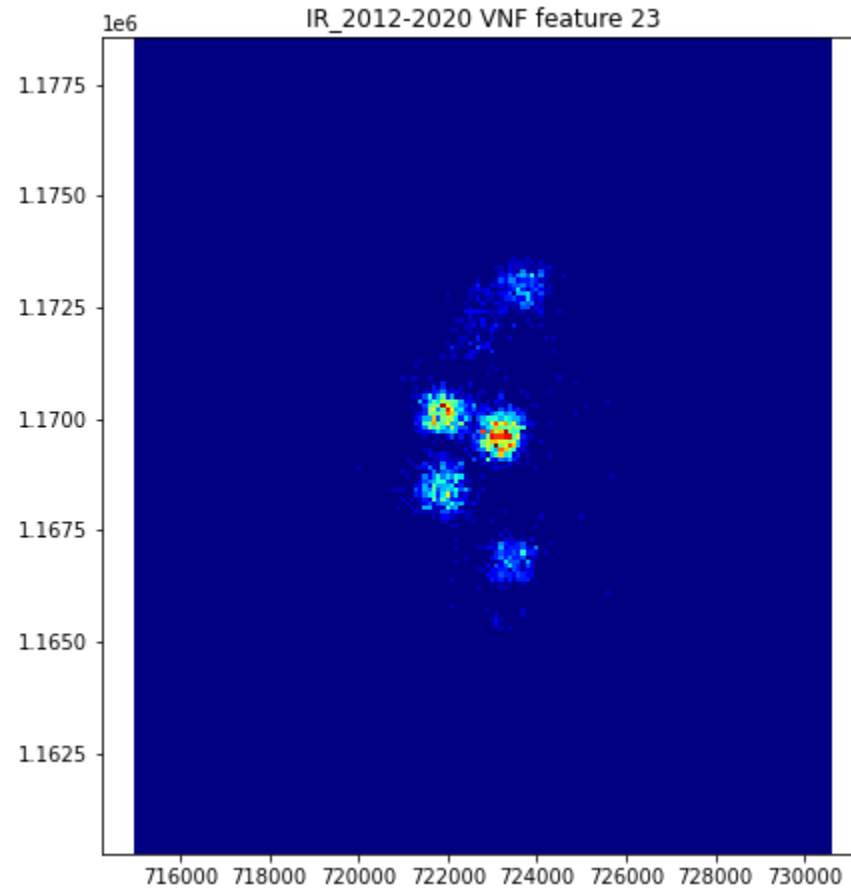
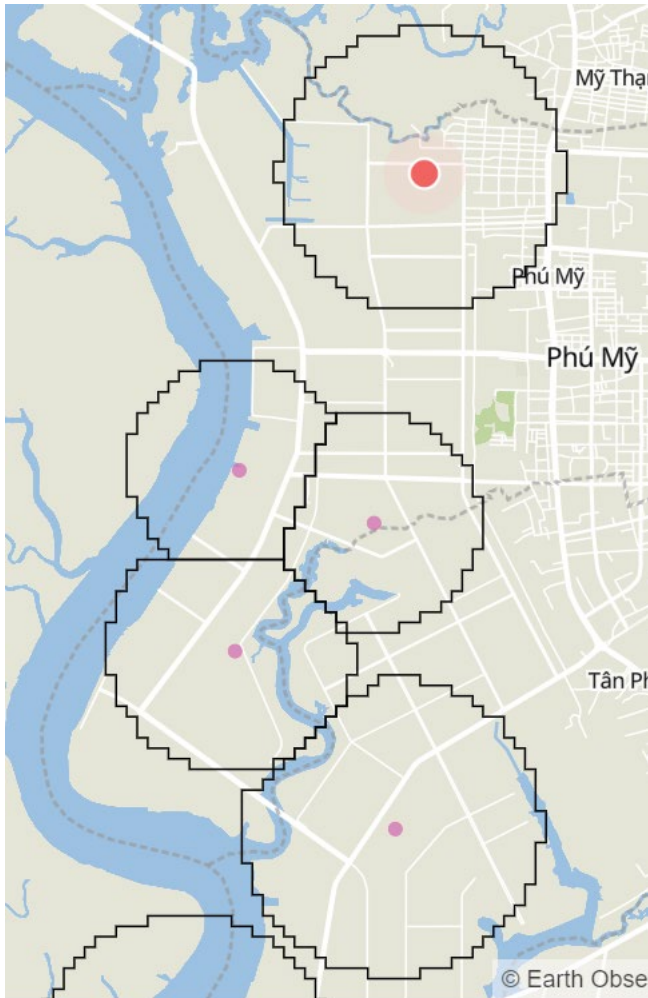


VNF v.4 primary and secondary emitters in Kalimantan, Indonesia 20230901



EOG has a web-map service tracking 20,000+ industrial emitters. The Global Infrared Emitter Explorer (<https://eogmap.mines.edu/giree>)

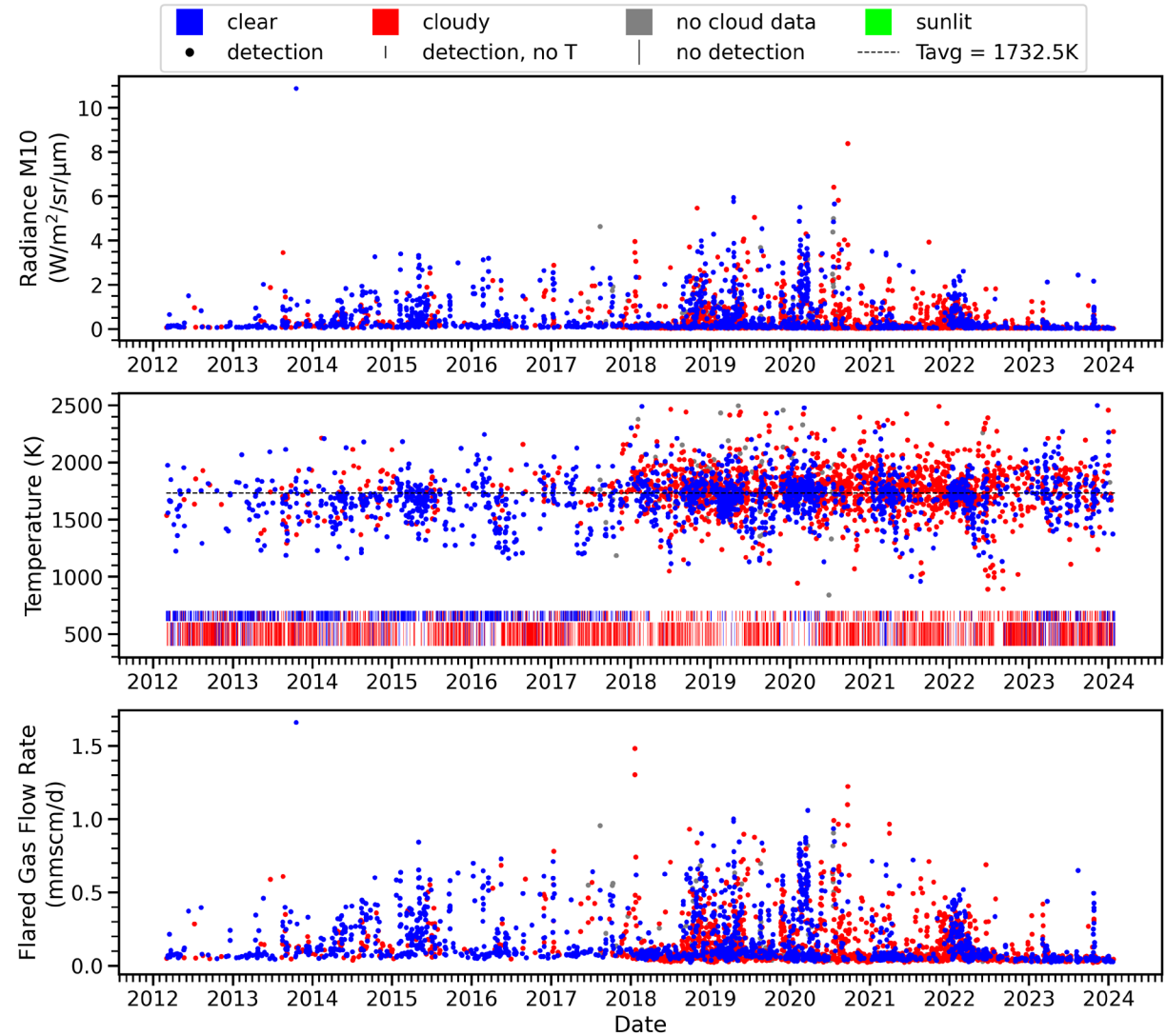
EOG has a multiyear catalog of industrial infrared emitters and a web map service (GIREE)



Gas Flare Offshore From Ho Chi Minh City



ISO: VNM Lat: 9.9726 Lon: 107.9709 Type: Upstream Flare Category: oil Satellites: SNPP & NOAA-20 ID: 2974



VIIRS Nightfire temporal profile created by the Earth Observation Group, Payne Institute for Public Policy, Colorado School of Mines
Last Updated: 2024-01-29 08:03:49 UTC

Summary

- EOG produces fire, flare and boat detections in near-real time.
- Using spectral bands ranging from near infrared to longwave infrared, EOG derives the IR emitter's Planck curve – from which temperature, source area and radiant heat are calculated using physical laws.
- The quickest way to receive EOG's nightly data is via email alerts. Let me know if you want VBD or VNF detection alerts for your country.
- With VNF data extending back to 2012 – EOG has derived temporal profiles for 20,000+ industrial IR emitters. These are updated once-per-week and are available from the GIREE web-map service.
- Three VIIRS sensors operate currently, two others are planned, assuring continuity until ~2040

The
Payne Institute
for Public Policy

 COLORADOSCHOOLOFMINES
EARTH • ENERGY • ENVIRONMENT

For more information, visit
<https://payneinstitute.mines.edu/eog/>
or email celvidge@mines.edu

Earth
Observation
Group